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Jay S. Hammond, Governor

Annual Performance Report for

COHO SALMON STUDIES IN THE RESURRECTION BAY AREA

by

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Section F

Job No. G-II-A
Coho Salmon Studies in the Resurrection Bay Area

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RESEARCH PROJECT SEGMENT

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Period Covered: July 1, 1976 to June 30, 1977.

ABSTRACT

Bear Lake was restocked with 224,600 age 0.0 coho salmon, Oncorhynchus kisutch (Walbaum), fingerlings on June 10 and 14, 1976 to maintain smolt production.

The Bear Creek weir downstream migrant trap was operated continuously from May 25 through September 17. A total of 93,311 age 1.0, 2.0 and 3.0 coho smolts were enumerated.

Smolt out-migration, timing and abundance, age and size compositions, condition factors, Bear Creek water temperatures and stream flows are presented. The increase in Bear Lake's age 1.0 smolt production due to lowered rearing coho population levels since 1975 is reviewed.

The Resurrection Bay creel census (July 8 - September 12) indicated an estimated 9,456 coho were harvested by 19,681 man-days of effort. The mean seasonal catch per hour was 0.084 coho. Marked (fin-clipped) adult coho contributed 22.0% to the sport harvest. Most of these (58.2%) survived from the 100,700 age 1.0, hatchery-reared, AD-LV marked smolts planted in Seward Lagoon in May, 1975. Adult survival of age 1.0, 2.0 and 3.0 Bear Lake smolts, Ad marked and released at Bear Creek weir in 1975 comprised 9.2% of the sport catch. Marked immature coho contributed an additional 3.6% to the harvest. These juveniles resulted from 100,600 age 1.0, hatchery-reared, Ad-LV marked smolts stocked in Seward Lagoon and 35,600 RV marked smolts released in Grouse Lake in May, 1975.

The Bear Creek weir upstream migrant trap was operated continuously from May 25 through November 30. The adult coho upstream migration extended from August 28 to November 14. The total migration consisted of 509 age 1.1, 2.1 and 3.1 Ad marked adults, 51 unmarked adults, and 23 jacks. Marine survival of age 1.1, 2.1 and 3.1 Bear Lake adults, including 155 that spawned below the weir, was 0.5%. The catch to escapement ratio of marked Bear Lake adult coho was 1.18:1. Total smolt-to-adult survival of the 1975 Bear Lake smolt out-migration was 1.1%. The adult male-to-female sex ratio was 2.1:1 in the Bear Lake escapement. An estimated

1,732,000 fertilized eggs were artificially spawned from 417 females and 86 males from the Seward Lagoon and Bear Lake returns. Mean fecundity was 4,153 eggs per female.

Data on the timing and abundance of other fish species ascending and descending Bear Creek to the weir are presented. Minimum coho escapements in seven index streams are discussed.

BACKGROUND

Wild coho, Oncorhynchus kisutch (Walbaum), production in Resurrection Bay is believed to be directly affected by the extreme fluctuations in stream flows and water temperatures characteristic of its drainage streams. Since 1961, the Resurrection Bay coho sport fishery has been the largest marine sport fishery for this species in Alaska. Therefore, there was a definite need to stabilize Resurrection Bay coho production to satisfy the rapidly growing angler demand in the fishery.

Bear Lake, located seven miles north of Seward, was chosen for coho rearing enhancement because it is the largest (445 acres) stable body of clear fresh water in the Resurrection River drainage, and is accessible by road. It was determined after a survey in 1962 that Bear Lake should be rehabilitated with rotenone to eradicate all predator and competitor fish species inhabiting the lake. Without predation and interspecific competition it was believed that Bear Lake would then produce a high sustained smolt yield from annual coho fingerling plants.

Pre-rehabilitation species abundances were measured by a temporary weir situated at the Bear Creek-Salmon Creek confluence from 1961 to 1964. Upstream migrations averaged 921 adult coho, (1961-1964); 4,801 adult sockeye salmon, Oncorhynchus nerka (Walbaum), (1961-1965); and 4,801 adult Dolly Varden, Salvelinus malma (Walbaum), (1961-1962). Downstream migrations in 1962-1963 averaged 7,933 coho smolts, 51,232 sockeye smolts, and 17,838 Dolly Varden. Though threespine stickleback, Gasterosteus aculeatus (Linnaeus), downstream migrations were not estimated at the weir, beach seine sampling indicated that this species was abundant in Bear Lake.

Bear Lake was rehabilitated with powdered rotenone at 1.0 ppm (5% level) on August 26, 1963. A 5-foot high dam was erected at the outlet to contain the treated water until detoxification and to prevent subsequent immigration of undesirable species. Bear Lake detoxified by October 17, 52 days after the water was treated, and received its first annual fingerling plant that winter through the ice. All fingerling plants except the 1966 release were fin-marked at Fire Lake Hatchery to facilitate smolt survival evaluation.

The Good Friday earthquake on March 27, 1964 destroyed the outlet dam, which washed out completely on May 25. This allowed unobstructed entry of all fish ascending Bear Creek into Bear Lake until June 15, when the barrier was repaired. A permanent weir was constructed 1,750 feet downstream from the outlet to assess Bear Lake's coho smolt production and returning adult migrations.

Bear Lake became reinfested with threespine sticklebacks. It is not known whether this was due to insufficient rotenone treatment or the destruction of the outlet barrier. Also, Dolly Varden were able to negotiate the weir during fall flood levels and immigrate into the lake during most years.

Before rapid expansion of the stickleback population occurred, Bear Lake's coho and sockeye smolt production increased several fold as a result of favorable rearing conditions from 1964 to 1966. Coho smolt biomass (weight) production attained 4.2 kilograms for each kg of fingerlings planted in 1964. Smolt age structures changed from predominantly age 2.0 to age 1.0 with growth exceeding that of former age 2.0 smolts. Smolt survival from stocked coho fingerlings reached 43.5% and 48.1% of the 1964 and 1965 plants, respectively. Had sufficient coho fingerlings been available for stocking Bear Lake at desired densities in 1963-1965, coho smolt production undoubtedly would have been considerably higher. Bear Lake's enhanced smolt production increased pre-rehabilitation abundances of adult sockeye and coho by 11 and 3.5 fold, respectively, for one complete life cycle.

Bear Lake's high smolt production was short lived, however, due to the sticklebacks' rapid takeover of the rearing environment beginning in 1967. Smolt age structures reverted to age 2.0 dominance, growth rates declined and fingerling-to-smolt survivals lowered. Coho fingerling plants were terminated after 1967 because smolt production was obviously dropping below pre-rehabilitation levels. By 1968, threespine sticklebacks had already reached pre-rehabilitation abundance in the lake.

In 1969, it was decided to rehabilitate Bear Lake again. Stickleback population sampling in 1970 showed that this species inhabited all areas and depths in Bear Lake. Bear Creek weir was reconstructed in 1969 and made entirely fish-tight by removing the sloping upstream fence and adding three permanent, perforated plate screens above the upstream migrant trap.

Bear Lake was rehabilitated again in 1971, and lake treatment was conducted essentially the same as in 1963 except 100% emulsified instead of powdered rotenone was used. Overall treatment level was 1.6 ppm rotenone at 5% concentration. Caged live fish suspended from surface to bottom (40 and 60 feet) were all dead within one week. Population sampling two days following rehabilition showed that threespine sticklebacks comprised 98.8% of the total sample (n=9,065) collected randomly on and around Bear lake. From this it was concluded that obtaining less than total lake rehabilitation in 1963 ultimately resulted in lower-than-normal salmon production in Bear Lake over the long term.

Bear Lake remained toxic through the winter of 1971-1972, and finally detoxified shortly after spring overturn. Annual coho fingerling plants in Bear Lake resumed in June, 1972 at desired stocking densities. Resultant smolts were enumerated, sampled weekly for age and size composition as well as condition factor, and fin-marked for recognition in the fishery before being released at Bear Creek weir. No threespine sticklebacks have been detected in Bear Lake during fall population

sampling by electrofishing or at Bear Creek weir since the 1971 rehabilitation.

RECOMMENDATIONS

1. Retain the present objectives of the study.

2. Construct a permanent coho adult trapping-holding facility in Seward Lagoon.

3. Continue to investigate the Resurrection Bay drainage for potential coho rearing pond sites.

4. Adjust the 1978 stocking density of coho fingerlings in Bear Lake according to emigrating smolt and residual fingerling abundance, age composition and condition factor in 1977.

5. Mark only 25% of Bear Lake smolt out-migrations to determine whether this reduced handling will result in improved smolt-to-adult survival.

OBJECTIVES

1. To determine the distribution, abundance, and timing of outmigrant and adult coho salmon in the Resurrection Bay area.

2. To determine the age and size composition of outmigrant and adult coho salmon populations in selected tributaries.

3. To determine the sport harvest and fishing mortality of coho salmon in Resurrection Bay.

4. To determine the methods and means of increasing or extending the freshwater spawning and rearing areas of the watershed, and mitigating freshwater mortality.

5. To provide recommendations for the management of coho salmon in these waters and direct the course of future studies.

TECHNIQUES

The timing and abundance of sockeye and coho smolts emigrating from Bear Lake downstream to Bear Creek weir were determined by enumerating these fish at the downstream migrant trap. Weir location and description of the downstream trapping facilities were presented by Logan (1969). The timing and abundance of adult sockeye and coho were measured by enumerating these fish at the weir's upstream migrant trap. Adult trapping facilities, rebuilt in 1969 and modified in 1970, were described by McHenry (1971). Bear Creek water temperatures and flows were recorded daily at the weir.

Age and size compositions of Bear Lake coho and sockeye smolt and residual coho populations were determined by weekly sampling at the weir and electrofishing in Bear Lake. Age structures of sockeye smolt and residual coho populations were determined by length-frequency analysis. Age compositions of the Bear Lake smolt and Resurrection Bay adult coho populations were estimated by examining representative scale impressions on 0.02-inch cellulose acetate with a Brunen model 200 microfiche. Age compositions of the adult Bear Lake sockeye and coho returns were not sampled because sockeye were known age (1.2) and wild coho produced below the weir were indistinguishable from Bear Lake smolts released unmarked in 1975. Size compositions of Bear Lake's sockeye and coho escapements were determined by sampling most fish for fork length, weight, and sex. All fish sampled were anesthetized in a 1:20,000 solution of MS-222 (Tricaine methanesulfonate) to facilitate handling and minimize mortality.

Resurrection Bay coho sport harvest and angler effort were measured by a stratified, random creel census conducted at the Seward small boat harbor. Sampling design and interview method were nearly identical to that described by Logan (1966). The average number and percentage of sport fishing boats returning to the Seward small boat harbor were determined for each of three 3.5-hour sampling periods extending from 11:30 a.m. to 10:00 p.m. Returning boats were not counted from 8:00 a.m. to 11:30 a.m. because only 11.6% and 14.3% of the weekend and weekday sport craft, respectively, returned during this period in the three years sampled (1964-1966). The mean number of boats returning during this morning period was extrapolated using the above percentages. These estimates were then added to those determined for the three periods sampled to estimate total daily boats. Fishing mortality and catch-to-escapement ratio of marked (fin-clipped) coho adults were determined by extrapolating the marked coho catch observed during creel census and by recording marked coho in the Bear Lake and Seward Lagoon escapements.

An index to coho escapement abundance was measured by conducting periodic foot surveys on seven local index streams throughout immigration until peak of spawning terminated. All carcasses were examined for clipped fins, sexed, and mutilated to preclude recounting on subsequent surveys.

Evaluation of Bear Lake's rehabilitated freshwater rearing environment was continued by measuring the abundance, growth and condition of smolts surviving from the 1973, 1974, and 1975 coho fingerling plants. Smolt biomass production was calculated by multiplying the seasonal mean smolt weight per age group by the total number of smolts emigrating per age group in 1976.

FINDINGS

Results

The findings presented are the result of the 1976-1977 research segment of the project. For a description of the Resurrection Bay drainage and past information collected on the project, see Logan (1962-1969) and McHenry (1970-1976).

Bear Lake Downstream Migration:

The Bear Creek weir downstream migrant trap was operated continuously from May 25 through September 17. The trap was removed on the latter date due to the beginning of flood flows resulting from heavy rains. Abundance and timing of the coho salmon, O. kisutch (Walbaum), smolt out-migration are shown in Table 1. Coho were designated "smolts" based on typical smolt characteristics (silvery pigment, loss of parr marks) rather than size alone. If the fish did not have these traits they were defined "fingerlings" regardless of size. All fingerlings were retained above the weir or restocked in Bear Lake if they were sufficiently abundant in the trap to warrant hauling by truck.

The smolt out-migration to the downstream trap totaled 93,311 smolts. Trap (0.1%) and marking/handling (0.5%) mortalities claimed 596 smolts, or 0.6% of the out-migration. A total of 92,715 live smolts were released downstream. All smolts received an adipose-right ventral (Ad-RV) fin-clip for recognition in the 1977 Resurrection Bay sport fishery and upon return to Bear Creek.

Smolt emigration began on June 2, peaked (50% of out-migration) June 27, and terminated September 17 when the trap was removed. The highest daily count occurred on June 20, when 6,067 (6.5% of the total run) were enumerated from the trap.

Mean stream temperatures when smolt emigration began, peaked, and terminated were 3.6°C, (38°F), 10.6°C (51.0°F), and 8.6°C (47.5°F), respectively. Bear Creek stream flows ranged from 19 to 74 cfs during this period. Mean fork length, weight, and condition factor of all smolts sampled by weekly periods are shown in Table 2.

The smolt out-migration was comprised of 68.7% (64,083) age 1.0, 30.2% (28,211) age 2.0, and 1.1% (1,017) age 3.0 smolts. Age group abundance was determined by extrapolating their relative percentages in biweekly scale sample analysis to the total number of smolts, emigrating during those periods. Tables 3, 4, and 5 show the mean fork length, weight, and condition factor of age 1.0, 2.0, and 3.0 smolts, respectively, in the biweekly samples. Table 6 presents the biweekly and seasonal abundance per smolt age group.

Out-migration timing peaked when Bear Creek water temperatures averaged 10.0°C (50°F) as it had in the past three years. Age 1.0 and 2.0 smolts peaked during June 24-30, while age 3.0 smolts peaked one week earlier. An estimated 63,674 age 1.0, 28,031 age 2.0, and 1,010 age 3.0 smolts were released downstream after mortality.

The 1,017 age 3.0 smolts resulted from the second fingerling plant (443,300 age 0.0 fingerlings in 1973) in Bear Lake after the 1971 lake rehabilitation project. Bear Lake coho fingerling plants since 1971 are summarized in Table 7, and smolt production since 1973 is presented in Table 8. Total fingerling-to-smolt survival for the 1973 plant was 49.3%, or 30% higher than that for the 1972 plant in Bear Lake. Age composition of the second Bear Lake smolt production cycle was 29.3% age 1.0, 70.2% age 2.0, and 0.5% age 3.0.

Table 1. Bear Lake Coho Salmon Smolts Enumerated at Bear Creek Weir by Weekly Periods, 1976.

Weekly Periods	Number of Smolts		
	Live	Dead	Total
5/27 - 6/2	2		2
6/3 - 6/9	6	1	7
6/10 - 6/16	1,824	1	1,825
6/17 - 6/23	28,424	221	28,645
6/24 - 6/30	31,054	138	31,192
7/1 - 7/7	18,108	152	18,260
7/8 - 7/14	6,135	12	6,147
7/15 - 7/21	3,833	22	3,855
7/22 - 7/28	1,092	8	1,100
7/29 - 8/4	683	28	711
8/5 - 8/11	624	7	631
8/12 - 8/18	75		75
8/19 - 8/25	60		60
8/26 - 9/1	386	5	391
9/2 - 9/8	2		2
9/9 - 9/15	333	1	334
9/16 - 9/22	74		74
Total	92,715	596	93,311

Table 2. Mean Fork Length, Weight, and Condition Factor of Bear Lake Coho Salmon Smolts Sampled Weekly at Bear Creek Weir, 1976.

Weekly Periods	Number Sampled	Mean Length (mm) ± SD	Mean Weight (g) ± SD	Condition Factor (K)*
6/10 - 6/16	100	106.2 ± 12.8	11.72 ± 3.14	0.98
6/17 - 6/23	100	109.2 ± 13.9	12.35 ± 6.06	0.95
6/24 - 6/30	100	116.9 ± 14.4	15.54 ± 6.56	0.97
7/1 - 7/7	100	117.5 ± 16.1	15.70 ± 8.78	0.97
7/8 - 7/14	100	120.2 ± 12.1	16.57 ± 4.93	0.95
7/15 - 7/21	100	127.9 ± 15.1	19.42 ± 7.50	0.93
7/22 - 7/28	100	145.1 ± 14.3	29.55 ± 9.31	0.97
7/29 - 8/4	100	140.5 ± 13.4	27.04 ± 8.37	0.97
8/5 - 8/11	100	159.1 ± 10.4	40.02 ± 7.03	0.99
8/12 - 8/18	75	154.2 ± 14.2	37.16 ± 11.01	1.01
8/19 - 8/25	60	160.5 ± 13.8	41.92 ± 10.37	1.01
8/26 - 9/1	100	169.4 ± 20.4	48.2 ± 12.11	0.99
9/9 - 9/15	100	175.4 ± 13.1	52.45 ± 12.68	0.97
9/16 - 9/22	74	178.6 ± 20.8	58.05 ± 20.12	1.02

*$K = \frac{Wx10^5}{L^3}$, where W = mean weight in grams, and L = mean fork length in millimeters.

Table 3. Mean Fork Length, Weight and Condition Factor of Age 1.0 Bear Lake Coho Salmon Smolts Sampled Biweekly at Bear Creek Weir, 1976.

Biweekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) ± SD	Mean Weight (g) ± SD	Condition Factor (K)
6/3 - 6/16	96	88.9	104.3 ± 6.4	11.03 ± 1.99	0.97
6/17 - 6/30	147	73.5	106.1 ± 7.3	10.95 ± 2.29	0.92
7/1 - 7/14	129	64.5	110.5 ± 6.5	12.72 ± 2.42	0.94
7/15 - 7/28	95	47.5	124.8 ± 10.5	19.09 ± 5.83	0.99
7/29 - 8/11	52	26.7	133.6 ± 9.6	23.56 ± 5.54	0.99
8/12 - 8/25	5	3.7	128.4 ± 13.4	21.52 ± 7.59	1.02
8/26 - 9/8*	2	2.0	136.0 ± 18.4	20.45 ± 11.53	0.81
9/9 - 9/22	2	1.2	124.5 ± 20.5	18.30 ± 3.11	0.95

* Only week of 8/26 - 9/1 sampled during this period.

Table 4. Mean Fork Length, Weight and Condition Factor of Age 2.0 Bear Lake Coho Salmon Smolts Sampled Biweekly at Bear Creek Weir, 1976.

Biweekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) ± SD	Mean Weight (g) ± SD	Condition Factor (K)
6/3 - 6/16	10	9.3	128.5 ± 12.0	20.47 ± 6.21	0.96
6/17 - 6/30	51	25.5	131.3 ± 10.8	21.58 ± 5.75	0.95
7/1 - 7/14	70	35.0	133.0 ± 8.4	21.47 ± 4.41	0.91
7/15 - 7/28	101	50.5	145.8 ± 13.4	28.30 ± 8.45	0.91
7/29 - 8/11	140	71.8	154.7 ± 12.2	36.44 ± 8.88	0.98
8/12 - 8/25	123	91.8	157.0 ± 12.2	38.99 ± 9.37	1.01
8/26 - 9/8*	84	84.0	167.2 ± 10.7	45.97 ± 9.59	0.98
9/9 - 9/22	132	78.1	171.5 ± 11.5	49.42 ±10.50	0.98

* Only week of 8/26 - 9/1 sampled during this period.

Table 5. Mean Fork Length, Weight and Condition Factor of Age 3.0 Bear Lake Coho Salmon Smolts Sampled Biweekly at Bear Creek Weir, 197

Biweekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm) ± SD	Mean Weight (g) ± SD	Conditio Factor (
6/3 - 6/16	2	1.8	178.0 ± 4.2	51.00 ± 2.12	0.90
6/17 - 6/30	2	1.0	161.0 ± 15.6	39.10 ± 11.31	0.94
7/1 - 7/14	1	0.5	205.0	83.40	0.97
7/15 - 7/28	4	2.0	178.3 ± 11.0	56.43 ± 14.59	1.00
7/29 - 8/11	3	1.5	176.7 ± 3.1	52.50 ± 3.84	0.95
8/12 - 8/25	6	4.5	181.2 ± 13.2	60.87 ± 12.06	1.02
8/26 - 9/8*	14	14.0	187.2 ± 9.4	64.26 ± 9.53	0.98
9/9 - 9/22	35	20.7	198.4 ± 12.1	76.33 ± 15.84	0.98

* Only week of 8/26 - 9/1 sampled during this period.

Table 6. Relative Abundance and Timing of Ages 1.0, 2.0 and 3.0 Bear Lake Coho Salmon Smolts Emigrating to Bear Creek Weir, 1976.

Biweekly Periods	Number of Smolts			Total
	Age 1.0	Age 2.0	Age 3.0	
6/3 - 6/16*	1,630	171	33	1,834
6/17 - 6/30	43,980	15,259	598	59,837
7/1 - 7/14	15,743	8,542	122	24,407
7/15 - 7/28	2,354	2,502	99	4,955
7/29 - 8/11	358	964	20	1,342
8/12 - 8/25	5	124	6	135
8/26 - 9/8	8	330	55	393
9/9 - 9/22	5	319	84	408
Total	64,083	28,211	1,017	93,311
Percent	68.7	30.2	1.1	100.0

* Includes two smolts captured during week of 5/27 - 6/2.

Table 7. Summary of Bear Lake Coho Salmon Fingerling Plants Since the 1971 Rehabilitation Program.

Brood Year	Source of Eggs	Number of Fish	Weight		Size		Density		Dates of Plants	Planting Method
			lbs.	kg.	No./lb	No./kg.	No./acres	No./Ha		
1971	Bear Lake	450,000	522	237.0	862	1,898	1,011	2,499	June 26, 27 1972	Truck at lake outlet
1972	Bear Lake	96,900	113	51.3	857	1,889	218	538	June 19	Truck-boat
	Lake Rose Tead	346,400	538	244.2	644	1,418	778	1,923	June 20	Scattered
	Total	443,300	651	295.5	681	1,500	996	2,461	1973	
1973	Upper Station	240,900	476	216.1	506	1,115	541	1,338	July 15	Truck-boat
	Upper Station	200,900	416	188.9	483	1,063	452	1,115	July 16	Scattered
	Upper Station	9,000	29	13.1	310	678	20	50	July 16	
	Total	450,800	921	418.1	489	1,076	1,013	2,503	1974	
1974	Bear Lake	245,600	454	206.1	541	1,192	552	1,364	June 19	Aircraft
	Bear Lake	204,400	455	206.6	449	989	459	1,135	July 1	Scattered
	Total	450,000	909	412.7	495	1,090	1,011	2,499	1975	
1975	Bear Lake	149,800	433	196.4	346	763	337	832	June 10	Aircraft
	Bear Lake	74,800	185	83.9	405	893	168	415	June 14	Scattered
	Total	224,600	618	280.3	363	799	505	1,247	1976	

Table 8. Summary of Bear Lake Coho Salmon Smolts and Biomass (kg) Produced from Annual Fingerling Plants Since the 1971 Lake Rehabilitation Program.

Year of Plant	Number and Weight (kg) planted	Smolt Production by Year (age group) 1973	1974	1975	1976	Total Production	Survival to Smolt (%)
1972							
Number	450,000	77,343	8,270	1,024		86,637	19.3
Weight (kg)	237.0	2,109.1	287.2	42.8		2,439.1	
Weight Ratio		8.9:1	1.2:1	0.2:1		10.3:1	
1973							
Number	443,300		64,119	153,525	1,017	218,661	49.3
Weight (kg)	295.5		1,462.2	3,182.6	71.7	4,716.5	
Weight Ratio			4.9:1	10.8:1	0.2:1	16.0:1	
1974							
Number	450,800			13,487	28,211	41,698	9.2*
Weight (kg)	418.1			155.9	1,029.5	1,185.4	
Weight Ratio				0.4:1	2.5:1	2.8:1	
1975							
Number	450,000				64,083		
Weight	412.7				915.6		
Weight Ratio					2.2:1		

* Data is minimal because it does not include age 3.0 smolts.

The 28,211 age 2.0 smolts were produced from 450,800 age 0.0 fingerlings stocked in 1974, and with the 13,487 age 1.0 smolts which emigrated in 1975, represent only a 9.2% fingerling-to-smolt survival thus far. Few age 3.0 smolts surviving this plant are expected in 1977, according to population sampling of Bear Lake's residual coho in October, 1976. Only 1.0% of the sample (n=500) were age 2.0 fish in the length-frequency analysis. Residual coho population samples obtained by electrofishing are shown in Table 9. Except for the few age 3.0 smolts anticipated in 1977, age composition of Bear Lake's third smolt production cycle was 32.3% age 1.0 and 67.7% age 2.0.

The 64,083 age 1.0 smolts resulted from the fourth annual Bear Lake plant of 450,000 age 0.0 fingerlings in 1975. Fingerling-to-smolt survival of this age group was 14.2% or 4.7 times the age 1.0 smolt survival (3.0%) of the previous fingerling plant. The aforementioned population sampling in Bear Lake, however, showed that only 7.2% of the residual coho were age 1.0 in 1976. Therefore, age 2.0 smolts in 1977 likely will not be abundant.

Smolt growth as the season progressed improved considerably over that observed in 1975. Age 1.0 smolts increased approximately 28 mm in fork length from migration peak to early August, whereas age 1.0 smolt growth in 1975 was almost nil during the same period. Similarly, age 2.0 smolts grew about 24 mm in fork length from migration peak to early August, compared to only 12 mm increase in 1975. Though average seasonal growth for both age groups was roughly half that observed in 1973 and 1974, it did show a marked improvement over that realized in 1975. It is believed this renewed growth resulted mainly from increased rearing area being available after the large age 2.0 smolt segment vacated Bear Lake early in 1975.

Though Bear Lake's annual smolt biomass production was low in 1976 (Table 8) considering all age groups present, it should improve substantially in 1977. Examining the ratio of age 1.0 smolt biomass (kilograms) yield per annual fingerling plant shows that it declined abruptly from 8.9:1 (1973) to 4.9:1 (1974) and 0.4:1 (1975), but then increased to 2.2:1 in 1976. Average seasonal condition factor for all smolts sampled per year exhibited a similar pattern: K=0.98 (1973), dropped to 0.90 (1974) and 0.89 (1975), but returned to 0.98 again in 1976. These suggest that Bear Lake may be recovering its optimum age 1.0 smolt production through lowered rearing population density and, hence, less intraspecific competion for fingerling growth and survival to early smoltification.

Population sampling in Bear Lake indicated its residual fingerling population still was fairly abundant despite the lake being restocked at only one-half previous stocking densities. Electrofishing the littoral zone along Bear Lake's southern shoreline on October 20, two shocker units captured 1,379 coho finerlings in 3.3 hours (418 fish/hour). This catch rate compares favorably with 462 fish/hour realized in 1973, and may reflect a similar degree of relative fingerling abundance in 1976.

Table 9. Age Composition of Bear Lake Residual Coho Populations Sampled By Electrofishing in October, 1972-1976. (Mean Fork Length Per Age Group in mm Shown in Parentheses).

Sampling Year	No. Fish Sampled	Catch Per Hour	Age Composition (%) *			
			0.0	1.0	2.0	3.0
1972	105	***	100.0 (76.6)			
1973	349	462	75.4 (88.1)	24.6 (131.2)		
1974	325	645	40.9 (73.4)	52.3 (124.4)	6.8 (163.8)	
1975	506	510	86.4 (77.0)	9.5 (114.7)	1.0 (159.6)	3.1** (192.0)
1976	500	418	91.2 (85.8)	7.2 (118.0)	1.0 (161.0)	0.6 (186.0)

* Determined by age group separation points in length-frequency analysis.
** Comprised of sexually mature males attempting to spawn.
*** Sample obtained by backpack shocker and beach seine.

Other Species:

The total sockeye salmon, O. nerka (Walbaum), smolt out-migration enumerated from the trap was 5,654 fish. Trap mortality claimed only eight smolts, or 0.1% of the downstream migration. The first smolt was captured on June 17 and the last on August 28. The highest daily count occurred on July 16 when 2,165 smolts (38.3% of the migration) were enumerated. The majority (98.3%) emigrated between July 15 and 21, when water temperatures ranged from 13.3° to 14.4°C (56 - 58°F), and stream flows from 25 to 29 cfs. The smolt out-migration was comprised of 4,780 (84.5%) age 3.0, 868 (15.4%) age 2.0, and 6 (0.1%) age 1.0 smolts. Age 3.0 smolts were produced by the 390 females and 331 males that spawned in Bear Lake in 1972. Including the 4,402 age 1.0 and 3,915 age 2.0 smolts which emigrated in 1974 and 1975, respectively total smolt production was 13,097 smolts (33.6 per female) for the first post-rehabilitation Bear Lake sockeye escapement. Age 2.0 smolts resulted from the 1973 escapement of 145 females and 91 males. With the 1,044 age 1.0 smolts produced by this parent brood in 1975, a total of 1,912 smolts (13.2 per female) have survived thus far. At peak of migration, age 1.0, 2.0 and 3.0 smolts averaged 119.5, 157.5, and 173.5 mm in fork length, respectively. Condition factors per age group during migration peak were 0.82, 0.86, and 0.83, respectively. Age 1.0 and 2.0 smolts in 1975 had condition factors of 0.90 and 0.98 during peak of migration.

A total of 20 Dolly Varden, Salvelinus malma, were captured in the downstream trap and released below the weir. No threespine sticklebacks, Gasterosteus aculeatus Linnaeus, were captured in the trap nor observed while electrofishing Bear Lake.

Resurrection Bay Coho Harvest and Effort:

A stratified, random creel census to determine the Resurrection Bay coho sport harvest and effort was initiated at the Seward small boat harbor on July 8 and terminated September 12. Very few coho were taken before the creel census began since most sport fishing effort was directed toward the more abundant rockfish, Sebastes spp., from mid-May through early July.

The season's total harvest was estimated at 9,456 coho. This estimate was extrapolated from interviews with 5,498 anglers harvesting 2,678 coho during the creel census period. Peak of the harvest occurred on August 14, first day of the Seward Silver Salmon Derby, when an estimated 414 fish (4.4% of the season's harvest) were taken. The season's total and derby harvests are summarized for 1972 through 1976 in Table 10.

The total sport fishing effort exerted for Resurrection Bay coho was an estimated 19,681 man-days. Approximately 28% of the season's effort was sampled during the creel census period. Total boats returning daily to the Seward small boat harbor are shown in Table 11. The average number of anglers per boats were as follows: weekdays, 3.28; weekends, 3.29; and the salmon derby, 3.19. Fishing effort and mean seasonal catch per hour are summarized in Table 12. The fishing effort was 6,186 man-days on weekdays and 5,074 on weekends, excluding the derby. Military personnel and dependents, fishing on boats provided by the Army and Air

Table 10. Derby and Total Sport Harvests of Coho Salmon in Resurrection Bay, 1972-1976.

Year	Total Sport Harvest	Derby Harvest	% Derby Harvest
1972	15,236	4,755	31.2
1973	13,911	4,334	31.2
1974	18,629	5,646	30.3
1975	19,793	3,799	19.2
1976	9,456	2,708	28.6

Table 11. Mean Number and Percentage of Sport Fishing Boats Returning to the Seward Small Boat Harbor During Each Sampling Period, 1976.

Periods (hours)	Weekends		Weekdays	
	Mean No. Of Boats	Percent	Mean No. Of Boats	Percent
8:00am - 11:30am*	9.9	11.6	5.2	14.3
11:30am - 3:30pm	19.1	22.5	7.3	20.3
3:00pm - 6:30pm	33.2	39.0	14.3	39.6
1:30pm - 10:00pm	22.9	26.9	9.3	25.8
Total	85.1	100.0	36.1	100.0

*Percentage for this period determined by three-year mean, 1964-1966.

Table 12. Derby and Total Sport Effort (Man-days) Exerted for Coho Salmon and Mean Catch Per Hour in Resurrection Bay, 1972-1976.

Year	Period of Census	Total Effort	Derby Effort	% Derby Effort	Catch Per Hour
1972	7/4 - 9/10	30,124	12,850	42.7	0.079
1973	7/7 - 9/9	24,301	9,885	40.7	0.095
1974	7/2 - 9/9	25,902	10,225	39.5	0.109
1975	7/9 - 9/7	20,047	5,871	29.3	0.135
1976	7/8 - 9/12	19,681	8,421	42.8	0.084

Force recreation camps at Seward, contributed 13.2% (2,604 man-days) to the total effort.

The seasonal mean catch per hour was 0.084 coho. Civilian anglers fishing on weekdays realized the highest coho catch per hour (0.128), whereas the lowest catch rate (0.050) occurred during the derby when effort was greatest. The average number of hours anglers fished per day were as follows: weekdays, 5.07; weekends, 5.33; and salmon derby, 6.47.

Examination of 213 scale samples randomly collected throughout the sport fishery disclosed that the wild coho population was comprised of 77.0% age 1.1, 21.6% age 2.1, and 1.4% age 3.1 adults. Mean fork lengths and weights of wild fish are presented in Table 13. The male-to-female sex ratio was 2.3:1 in the fishery.

Scale analysis of sport harvests during the past five years indicates the dominant age group of wild Resurrection Bay coho populations has changed from age 2.1 (4-year old) to age 1.1 (3-year old) fish. Table 14 shows the age composition trend since 1972.

Chinook, O. tshawytscha (Walbaum), and pink salmon, O. gorbuscha (Walbaum), were taken incidentally with coho during the season. An estimated 433 chinook salmon were harvested during the census period at an average rate of 0.08 per boat. This species was most abundant from late July to early August when anglers averaged 0.32 fish per boat. Most chinook salmon taken were immature fish in their first and second ocean years. Origins of these stocks are unknown as chinook salmon rarely ascend Resurrection Bay streams.

Table 13. Mean Fork Length (mm) and Weight (kg) of Wild Adult Coho Salmon Sampled from the 1976 Resurrection Bay Sport Fishery.

	Number of Fish	Mean Length (mm) and SD	Mean Weight (kg) and SD
Males	160	683.1 ± 62.1	4.54 ± 1.38
Females	70	673.4 + 47.4	4.22 + 1.02
Total	230	680.1 ± 58.1	4.45 ± 1.29

Table 14. Age Composition of Wild Resurrection Bay Coho Populations as Determined by Scale Analysis of Randomly Sampled Sport Harvests, 1972 - 1976.

Year	Sampling Period	No. of Fish	Age Composition (%) 1.1	2.1	3.1	Total
1972	7/4 - 9/4	179	34.7	59.2	6.1	100
1973	7/7 - 9/2	201	42.8	49.7	7.5	100
1974	7/2 - 9/1	236	49.1	49.2	1.7	100
1975	7/9 - 9/11	250	58.0	35.2	6.8	100
1976	7/8 - 9/3	213	77.0	21.6	1.4	100

The Resurrection Bay pink salmon return in 1976 was about 1.6 times as large as the previous highest year, 1970, according to the seasonal sport catch. In 1970, an estimated 3,784 pink salmon were taken, compared to the record 6,021 caught in 1976. Commercial Fisheries Division escapement records indicate the 1976 pink salmon escapement count was about twice that of 1974 (Schroeder, personal communication). A limited commercial purse seine fishery held on August 9 and 10 harvested approximately 35,000 pink salmon by only five seiners in 30 hours total fishing time. Pink salmon were most abundant in the sport fishery from late July through early August when anglers averaged 2.76 fish per boat. Pink salmon catch per man-day averaged 0.75 in 1976 compared to 0.39 for the 1974 season.

Table 15. Bear Lake Adult Coho Salmon Enumerated Through Bear Creek Weir by Weekly Periods, 1976.

Weekly Periods	Ad-Marked	Unmarked	Male	Female	Total
8/26 - 9/1	3		3		3
9/2 - 9/8	1		1		1
9/9 - 9/15	98	8	80	26	106
9/16 - 9/22	264	33	201	96	297
9/23 - 9/29	92	7	67	32	99
9/30 - 10/6	37	3	21	19	40
10/7 - 10/13	7		3	4	7
10/14 - 10/20	4			4	4
10/21 - 10/27	2			2	2
10/28 - 11/3					
11/4 - 11/10					
11/11 - 11/17	1		1		1
Total	509	51	377	183	560

Bear Lake Upstream Migration:

The Bear Creek weir upstream migrant trap was operated continuously from May 25 through November 30. The first adult coho entered the trap on August 28 and the last one was captured November 14. An estimated 155 Bear Lake coho remained below the weir to spawn, according to foot surveys made after most of the adult run had entered the trap.

A total of 560 adults and 23 jacks were enumerated from the trap. Abundance and timing of the adult coho migration are shown in Table 15.

The migration peaked (50%) on September 19, and the highest daily count of 71 fish (12.5% of the run) occurred on September 16. Mean stream temperatures at the beginning, peak, and end of migration were 11.1°C (52°F), 8.1°C (46.5°F), and 1.1°C (34°F), respectively. Most of the migration (96.7%) occurred from September 9 through October 6 when Bear Creek temperatures ranged from 5.6° to 10.0°C (42°-50°F) and flows, from 39 to 150+ cfs. The latter flow was estimated when Bear Creek reached flood stage between September 18 and 22 with the weir head level running over the pool depth gauge.

All returning marked adults resulted from the 1975 out-migration of 143,589 age 1.0, 2.0 and 3.0 smolts marked and released past the weir. Unmarked adults resulted both from Bear Lake smolts inadvertently released unmarked and from natural smolt production below the weir in 1975. With an estimated 19 Ad marked adults taken in the shore fishery and the additional 155 adult coho observed spawning in lower Bear Creek, the total adult escapement was an estimated 734 fish. Therefore, marine survival of the 1975 smolt out-migration was only 0.5% return to Bear Creek.

Five Ad-RV marked jacks enumerated from the trap returned prematurely from the 1976 Bear Lake smolt out-migration. Sixteen Ad-LV jacks returned from a Hatchery Services release of 35,600 age 1.0 (1974 brood Bear Lake origin) smolts in Bear Creek below the weir from May 12-14, 1976.

Most of the Department's coho egg requirements for the Southcentral region's needs were obtained from Bear Creek and Seward Lagoon returns. A total of 207 males and 538 females were held to ripen in the Bear Creek holding facility from September 10 to November 24. Stream temperatures ranged from 0° to 11.1°C (32° to 52°F) during this period. Male and female holding mortalities were 26.6% and 22.5%, respectively.

A total of 417 females and 86 males were artificially spawned, yielding an estimated 1,732,000 fertilized eggs. Mean fecundity was 4,153 eggs per female. Eggs were fertilized at an average ratio of 1 male: 4.8 females. Dead egg loss after shocking at Fire Lake hatchery averaged 7.9% (Wallis, personal communication).

Mean fork lengths of adult Bear Lake coho measured at the weir were 692.2 and 691.0 mm for 152 males and 85 females, respectively. The male-to-female sex ratio, excluding jacks, was 2.1:1 in the Bear Lake escapement. All spawned carcasses were deposited in Bear Lake for natural fertilization.

Other Species:

A total of 576 adult and 2 jack sockeye salmon were captured in the upstream trap from June 2 to August 10. All were age 1.2 as they resulted from the 1974 out-migration of 4,402 age 1.0 smolts produced by the 1972 Bear Lake escapement. Smolt-to-adult survival thus far is 13.1%, with additional three-ocean fish expected to return from this out-migration in 1977. The two jacks were age 1.1 as determined by

scale analysis. Mean fork lengths for 146 males, 139 females and 2 jacks sampled at the weir were 577.1, 530.8, and 373.5 mm, respectively.

Upstream migrating Dolly Varden ascended Bear Creek to the weir in early July and continued moving in and out of the trap throughout the remaining field season.

Pink salmon first entered the trap on July 21, and eventually moved downstream to spawn from mid-August to mid-September. An estimated 10,030 pink salmon spawned in lower Bear Creek in 1976 (Schroeder, personal communication).

All fish other than sockeye or coho salmon were retained below the weir.

Adult Coho Timing and Abundance in Index Streams:

Peak of the 1976 index escapements varied from mid-October to late November, and peak of spawning generally occurred within the following two weeks after escapements peaked in each index area. Minimum coho escapements in each stream index area since 1972 are presented in Table 16.

The total combined index escapement of 342 adults in 1976 is about 57% greater than the 1973 parent brood escapement that mainly produced it, and 39% larger than the previous cycle (1972-1975) mean.

Fin Marked Coho Returns:

Marked adult coho contributed 22.0%, or an estimated 2,078 fish, to the 1976 Resurrection Bay sport harvest. A total of 1,209 (58.2%) of these fish resulted from 100,700 age 1.0 (1973 brood, Bear Lake origin) hatchery-reared, Ad-LV marked smolts stocked in Seward Lagoon in May, 1975. An additional 869 Ad marked adults caught returned from 143,589 age 1.0, 2.0 and 3.0 Bear Lake smolts marked and released at Bear Creek weir in 1975.

Marked coho spawning escapements bound for Seward Lagoon and Bear Creek were estimated at 1,016 Ad-LV and 734 Ad adults, respectively. These escapements include 343 Ad-LV and 19 Ad coho estimated taken in the shore fishery after the Resurrection Bay sport trolling season terminated. Total smolt-to-adult survival for the Seward Lagoon coho, including 2,559 age 1.0 Ad-LV immatures and jacks caught in 1975, was 4.8%. Smolt-to-adult survival of Bear Lake smolts was 1.1%. The overall catch-to-escapement ratio of marked Seward Lagoon and Bear Lake adult coho was 1.19:1.

In addition to the marked adult catch, an estimated 338 marked immatures and jacks contributed 3.6% to the sport harvest. The fish resulted from 100,600 age 1.0 (1974 brood, Bear Lake origin) hatchery-reared, LV marked smolts stocked in Seward Lagoon from May 4-10, and 35,600 RV marked smolts (same age and origin) released in Grouse Lake from May 10-12, 1976. Age 1.1 adults surviving from these smolt plants will return in 1977. The total marked coho contribution to the Resurrection Bay fishery, including adult and immature fish, was 25.6% in 1976.

Table 16. Minimum Coho Salmon Escapement in Seven Index Streams in the Resurrection Bay Area, 1972-1976.

Name of Stream	Minimum Escapement 1972	1973	1974	1975	1976	Mean 1972-75
Airport	15	4	23	2	24	11
Box Canyon	59	36	28	8	45	33
Clear	55	37	60	15	89	42
Dairy	49*	63*	114*	32*	17*	64*
Grouse	42	34	64	12	27	38
Jap	68	40	77	31	94	54
Mayor	22	4	51	5	46	21
Total	310	218	417	105	342	263

* Does not include marked jacks or adults returning from hatchery-reared smolt releases.

DISCUSSION

Bear Lake has been stocked annually with coho since the 1971 lake rehabilitation at densities ranging from 996 to 1,013 fingerlings per surface acre. The cumulative effect in just three years (1972-1975) resulted in critically overstocking Bear Lake's coho rearing habitat.

Intense intraspecific competition among fingerlings evidently depressed growth rates, lowered survivals, and extended rearing duration to attain smoltification. Mean seasonal condition factors of all smolts sampled each year were observed to drop from 0.98 (1973) to 0.90 (1974) and 0.89 (1975). The percentage of fingerling plants resulting in age 1.0 smolts also decreased from 17.2% (1973) to 14.5% (1974) and just 3.0% (1975). Similarly, biomass ratios of age 1.0 smolts produced per fingerling release declined abruptly from 8.9:1 (1973) to 4.9:1 (1974) and 0.4:1 (1975).

Increased stress from overcrowding apparently led to greater susceptibility (lowered resistance) of rearing fingerlings to natural diseases in Bear Lake. Though the 1975 smolt out-migration (168,036 smolts) was the largest ever recorded for Bear Lake, over 91% were age 2.0 smolts in relatively poor condition. Nearly 13% of the smolt run died from "eye fluke", Diplostomulum spathaceum, and fungus, Saprolegnia sp., diseases at the weir. Only 1.1% of the 143,589 smolts released in 1975 survived to return as adults in 1976.

A downward adjustment in Bear Lake's fingerling stocking density was therefore clearly indicated from these findings. Bear Lake was stocked in 1976 at only 505 per acre, or approximately one-half previous levels, to enhance fingerling growth and survival to smolts. The result, in conjunction with the additional rearing area being available after the large age 2.0 smolt segment emigrated in 1975, was a substantial improvement in growth, condition and survival of age 1.0 and 2.0 smolts in 1976. Also, growth and survival of age 0.0 fingerlings stocked in 1976 appeared to be excellent. It is anticipated that a large proportion of this age group will emigrate as age 1.0 smolts in 1977.

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